Technical Paper T-120

FROM ROOFING SHINGLES TO ROADS

by J. Don Brock, PhD., P.E.

ASTEC encourages its engineers and executives to author articles that will be of value to members of the Hot Mix Asphalt (HMA) industry. The company also sponsors independent research when appropriate and has coordinated joint authorship between industry competitors. Information is disbursed to any interested party in the form of technical papers. The purpose of the technical papers is to make information available within the HMA industry in order to contribute to the continued improvement process that will benefit the industry.

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INTRODUCTION

There are 77 plants in the United States producing roofing shingles. These 77 plants produce approximately 12.5 billion square feet of shingles per year, weighing in excess of 13,000,000 tons. Approximately 65% of the shingles are used for restoring roofs on houses and 35% on roofs for new houses. For each roof that is restored, the equivalent amount of old shingles are removed and must be discarded. In addition to this, each roofing plant in the United States generates asphalt factory scrap materials and seconds that amount to approximately 10% of their production. The tabs or cutouts equate to 1% by weight.

Tabs from the roofing shingles have multiple uses and do not present a disposal problem. However, the seconds and the factory scrap from the operations pose a very difficult problem for the shingle manufacturer. Some plants are being forced to haul the scrap material as far as 300 miles away, costing as much as $60 per ton for disposal of their product. Landfills across the country are charging a minimum of $18 per ton and as high as $100 per ton to accept roofing shingles.

From the above, it is apparent that the largest volume of shingles is in the tear-offs. These also are subject to the most contamination and require a more complex system to separate the nails, paper, etc., from the product.

F1

	Organic (lbs. per 100 sq. ft.)	Organic (%)	Fiberglass (lbs. per 100 sq. ft.)	Fiberglass (%)	Old (lbs. per 100 sq. ft.)	Old (%)
Asphalt	68	30	38	19	72.5	31
Filler	58	26	83	40	58	25
Granules	75	33	79	38	75	32
Mat	0	0	4	2	0	0
Felt	22	10	0	0	27.5	12
Cut-out	(2)	1	(2)	1	0	0
TOTALS	221		202		235	

Roofing Shingle Analysis

F2

	Organic	Fiberglass	Old
Asphalt @ 400.00/ton	$120.00	$76.00	$124.00
Filler @ 10.00/ton	2.60	2.80	2.50
Granular @ 10.00/ton	3.33	2.66	3.20
Mat @ 10.00/ton		.14	
Felt @ 10.00/ton	1.00	.07	1.20
Sub-totals	126.93	81.67	130.90
Disposed cost	25.00	25.00	25.00
Sub-totals	151.93	106.67	155.90
Process cost	(10.00)	(10.00)	(12.00)
NET VALUE	141.93	96.67	143.90

Savings in hot mix asphalt (per ton)	Organic	Fiberglass	Old
4%	$5.68	$3.86	$5.76
5%	7.10	4.83	7.19
6%	8.32	5.80	8.63

Hot Mix Savings Using Roofing Shingles

F3

MARSHALL PROPERTIES AT OPTIMUM ASPHALT CONTENT

Stability at 140˚F, lbs	2380.0
Flow at 140˚F, 0.01"	12.3
Unite Weight, lb/ft³	148.5
Voids Analysis, %:	
Air Voids	4.4
Voids Mineral Aggregate	*18.6
Voids Filled	*76.0

* Calculated assuming no asphalt absorption into aggregate

Aggregate Proportions (Cold Feed):
54% No. 8 Stone, 46% Screenings

JOB MIX FORMULA

Sieve Size	Percent Passing
3/4"	100.0
1/2"	99.0
3/8"	96.0
No. 4	59.0
No. 8	40.0
No. 16	23.0
No. 30	13.0
No. 50	7.0
No. 100	4.0
No. 200	3.2
Asphalt content, %	6.0

*5.1 % added

Typical Surface Mix

HOT MIX ASPHALT WITH ROOFING SHINGLES

The composition of roofing shingles varies depending on the type of base material. Modern roofing shingles usually have either an organic or fiberglass base material. Older roofing shingles typically have a somewhat different composition than those produced more recently. Material contained in roofing shingles is given per roofing square (**Figure 1**).

Net realized value of the shingles is based on the following assumptions and can be calculated for each shingle type (**Figure 2**).

- **asphalt cost of $400 per ton**
- **aggregate cost of $10 per ton**
- **disposal cost of $25 per ton**
- **processing cost of $10 for fresh, factory roofing scraps**
- **old, torn-off roofing, $12 per ton**

A typical mix design utilizes 6% liquid asphalt (**Figure 3**). Some of the liquid asphalt content for this typical mix design can be contributed by injecting 5% fiberglass-based roofing shingles (**Figure 4**). Organic-based shingles at 5% would contribute even more liquid asphalt (**Figure 5**). Little changes in the mix property occur, as can be seen from the tables. Of course, each mix specification would need to be evaluated to determine the effect of roofing as a mix component. Actual liquid asphalt savings will depend on the optimal results from mix design testing.

Experiments, conducted at a plant operation in Orlando, Florida, have shown that the use of 4–10% roofing shingles can increase the performance of the mix considerably. Parking lots at Disney World, where 10% of asphalt fiberglass-shingle were used, have successfully demonstrated excellent performance over 20 years. High traffic of heavy trucks on entrance roads of an asphalt plant in Orlando have shown the mix made with fiberglass shingles to demonstrate much better performance than normal asphalt mixes due to the additional strength added by the fiberglass.

SHREDDING AND INTRODUCTION INTO THE MIX

As a result of many years of research by the Astec Division of Astec Industries, Inc., it has been determined that the shingles need to be shredded to at least 1/2 inch or smaller prior to introduction to the mix. The small size is necessary to insure proper melting of the shingles and uniform introduction into the asphalt mix.

Astec first utilized a modified wood hog to process the shingles. One of the major problems was in the handling and separation of the stacks of shingles. While the wood hog worked successfully, its maintenance costs were unacceptably high.

A second system was developed utilizing a slow speed shredder, similar to that used for automobile tires, plus a second-stage hammer mill. Again, this worked successfully in shredding the product but the maintenance was excessively high. The roofing granules used in the shingle process come from some of the hardest aggregate in the United States. The hardness seems to come with the opaqueness to light. While these granules are somewhat loosely attached with the asphalt cement to the backing material, and the shredding process is conceptually only necessary to shred the backing of the material, the granular material leads to excessively high wear.

Today, most shingles are shredded with large wood chippers. A typical wood chipper with 500hp will shred approximately 50-75 tph (**Figure 6**). To reduce the shingle to 1/2 minus the material is usually shredded twice. To insure a consistent product the system shown (**Figure 7**) is recommended. Here a wood chipper feeds the shredded product onto a belt where it is mixed with approximately 20% aggregate (-4 mesh) to prevent the shingles from sticking together. The mixture is then fed into a trommel screen where any over size +1/2 material is separated and recirculated back to the shredder to be reprocessed. This insures that the entire product is less than 1/2 minus.

The mixing of the fine aggregate with the shredded shingles is less necessary in colder climates and when processing tear-off (older shingles).

F4

MARSHALL PROPERTIES AT OPTIMUM ASPHALT CONTENT	
Stability at 140˚F, lbs	1950.0
Flow at 140˚F, 0.01"	13.8
Unite Weight, ^{3}lb/ft	149.3
Voids Analysis, %:	
Air Voids	4.5
Voids Mineral Aggregate	*18.9
Voids Filled	*81.0

* Calculated assuming no asphalt absorption into aggregate

JOB MIX FORMULA Sieve Size	Percent Passing
3/4"	100.0
1/2"	99.0
3/8"	96.0
No. 4	57.0
No. 8	39.0
No. 16	24.0
No. 30	14.0
No. 50	9.0
No. 100	6.0
No. 200	4.2
Asphalt content, %	*6.0

*5.1 % added

Aggregate Proportions (Cold Feed):
55% No. 8 Stone, 40%Sand, 5% Glass Shingle

Mix Utilizing 5% Fiberglass Roofing Shingles

F5

MARSHALL PROPERTIES AT OPTIMUM ASPHALT CONTENT	
Stability at 140˚F, lbs	1550.0
Flow at 140˚F, 0.01"	13.8
Unite Weight, ^{3}lb/ft	145.5
Voids Analysis, %:	
Air Voids	4.5
Voids Mineral Aggregate	*19.5
Voids Filled	*78.0

* Calculated assuming no asphalt absorption into aggregate

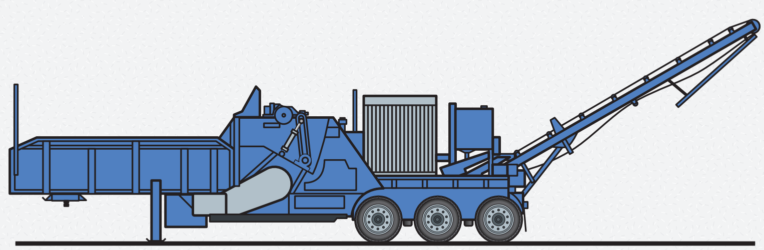
JOB MIX FORMULA Sieve Size	Percent Passing
3/4"	100.0
1/2"	99.0
3/8"	96.0
No. 4	58.0
No. 8	39.0
No. 16	23.0
No. 30	13.0
No. 50	8.0
No. 100	5.0
No. 200	3.5
Asphalt content, %	*6.0

*4.5 % added

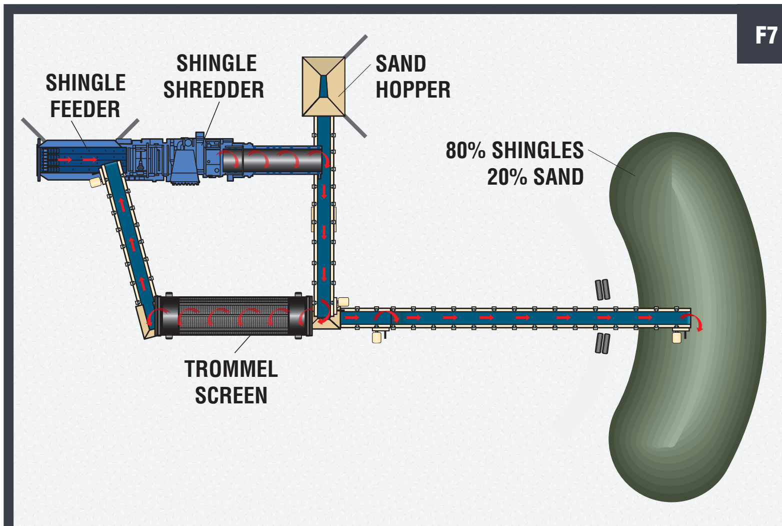
Aggregate Proportions (Cold Feed):
53% No. 8 Stone, 42%Sand, 5% Organic Shingle

Mix Utilizing 5% Organic Base Roofing Shingles

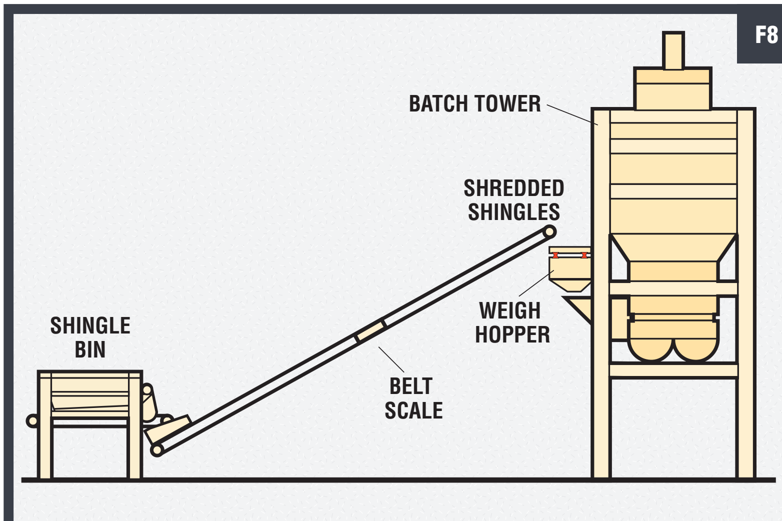
F6



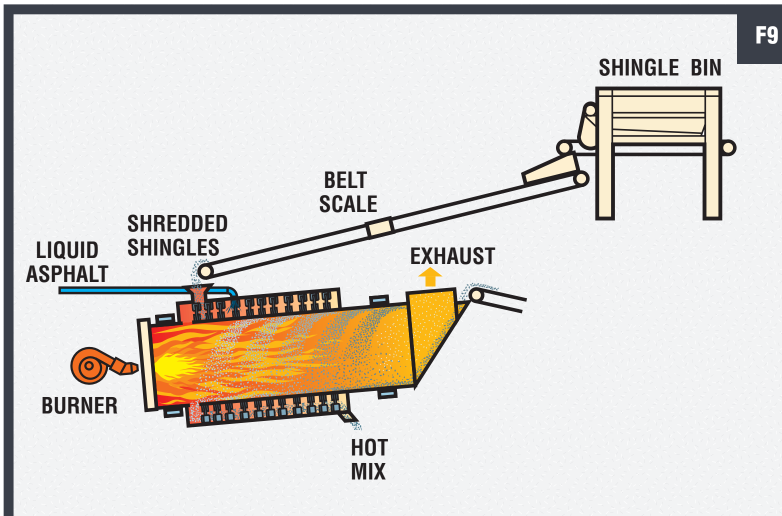
Typical 500 HP Shingle Shredder



Typical Shingle Shredder Plant



Shingles Fed Directly to Batch Plant



Shingles Fed Directly to Double Barrel

To properly melt and mix the shingles into the hot mix asphalt, slightly longer mixing times are usually required. Shingles can be fed into a batch plant (**Figure 8**) or into a continuous Double Barrel (**Figure 9**). It is not recommended that shingles be fed into counterflow drum mixers with imbedded burners due to the short mixing time. If this is required a finer grind of 1/4" is required.

ECONOMICS

For purposes of this paper, value of the roofing shingles is based on $400 per ton liquid asphalt, $10 per ton aggregate, $25 per ton disposal fee and $10-$12 per ton processing cost. The paper illustrates the economics of introducing various percentages of fiberglass, organic and old shingles back into the hot asphalt mix. Clearly, the economic benefits are very attractive. By introducing 5% organic shingles, the hot mix asphalt cost can be reduced by $7.10 per ton (**Figure 2**).

Considering the used shingles removed from roofs, plus the additional asphaltic wastes from the plants, there are nearly 10,000,000 tons of recyclable roofing materials available each year. This equates to about 2,000,000 tons of liquid asphalt annually. This could supply approximately 6% of the liquid asphalt needed in all the asphalt mix produced in the United States each year. This would also be a sufficient quantity of shingles to add 1.4% into every ton of mix, reducing the cost by $1.35* per ton. Considering the value of the old shingles as shown in **Figure 2**, a disposal cost of $25 per ton and a processing cost of $12 per ton, approximately $945,000,000 could be saved by the hot mix asphalt industry each year if all the recyclable roofing shingle in the United States were used. Based on $45 per ton for mixing, trucking and placing the hot mix asphalt, 21,000,000 additional tons of hot mix could be available for resurfacing our road system in the United States, while 8,450,000 less tons of material would be placed in our landfills.

As can be seen from the data above, roofing shingles in hot mix asphalt create an excellent opportunity for the hot mix industry to reduce cost while eliminating a major environmental problem.

*If all were fiberglass w/19% liquid.

ASTEC, INC. an Astec Industries Company
4101 JEROME AVENUE • CHATTANOOGA, TN 37407 USA • 423.867.4210 • FAX 423.867.4636 • astecinc.com

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